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RESEARCH ARTICLE

Efforts on Geological Conservation to Watuadeg-Basalt Pillow Lavas at West Sumber, Berbah District, Sleman Regency, Yogyakarta Special Region-Indonesia

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Abstract

Site of Berbah pillow lavas is an important geological heritage that is currently as one of the main tourism destination area located in Yogyakarta Special Region, Indonesia. It has a unique appearence of pillow structures with diameters of 0.5-1.0 m and the flow length of 2-5m.The pillow structures are interpreted as product of deep sea volcanism, that happening during Late Oligocene to Early Miocene. This site is used to visited by students and earth researchers becouse of its unique geological history, i.e as submarine ancient volcano. This study was approached with geotourism and geoconservation points of view. The research method uses qualitatively field geological observations. Data analysis was carried out by assessing the feasibility study of the geological conditions that had been produced in relation to the development of educational tourism. In its condition, this site ever suffered damage by the development impacts in the surrounding area and was once an object of agate mining so that its condition was increasingly not maintained. In order to maintain this site and become a protected geological site, there must be seriousness of various parties in an effort to map the geological conditions of the pillow lava complex, an important role that geologists have to inform and disseminate to all stakeholders and local residents to be able to independently manage the potential of geotourism. In addition, it also needs the local government commitment in protecting the object of pillow lava and struggle for it to become a protected geological reserve.

Keywords: pillow lava, basalt, geotourism, damage and geoconservation

1. Introduction

The study area is located in the east of Yogyakarta Special Region, precisely located on the lips of the Opak River with coordinates 7º 42 '5 "S and 110º 26' 35" E (Fig. 1). The area has a variety of geological processes, supported by natural and geological resources with potential geoheritage objects focussing on panoramic aspects and geology. Not only for the natural tourism, cultural tourism and geological tourism, but also for cullinary and shopping tours.

Watuadeg basalt pillow lava was a main geological site in Yogyakarta, for students and volcanologist to studying submarine ancient volcano. Now, this area has been manuvered to become a major tourism destination in Yogyakarta together with breccia's cliff located 5 km east of the study area and Ancient Nglanggeran Volcano located about 20 km to the southeast. The development of the geoheritage is certainly very good for the people who live around it. However, every development certainly produces changes in land form, which inevitably will eliminate some of the related geological data. This also applies to the Watuadeg Geoheritage of the Basalt Pillow Lava. The study is focussed on the impact of the occurence of the geoheritage; producing more benefits or disadventages for geological educational interests.

2. Geotourism

In a fact, the concept of geotorism is not to different with geopark concept. In Indonesia, geotourism is development of a region based on a sustainable manner that combines three diversities, namely: geodiversity, biodiversity, and cultural diversity (Yuliawati et al., 2016). Mulyaningsih et al (2009) argued that Watuadeg basalt pillow lavas were volcanic deep sea materials. The pillow lava was originally a high-temperature liquid magma resulting from a volcanic eruption that froze quickly due to being exposed to sea water to form lumps resembling a pillow formation. These pillow lavas can be used as evidence to show the initial process of forming ancient volcanoes on the island of Java. Determination of an area into an object of geoheritage will have a considerable impact on the

community around the area. In addition, the impact caused in the geoheritage sector also has a very large effect in it; in the economic, social and cultural fields.

According to Newsome & Dawling (2006), geotourism should be covered geographical, cultural, social economic which sit under the scope of geographic tourism. In the implementation of the development of tourism, whatever ideas are implanted, it will affect to the social, economic, cultural, livestyle and environment, such as its ecosystem and landuse. This has happened in the development of geotourism in Bromo-Tengger (Hakim et al., 2017), Lake Toba (Ginting et al., 2017), Nglanggeran (Abidin, 2017) and others (Yuskar, 2016).

At the Watuadeg pillow lava, the local government has made efforts to preserve and maintain this geological site. These efforts include: the existence of homestays in this region so that it can have an impact on the welfare of the surrounding residents, the infrastructureconstruction connectingthe pillowlava and other geoheritage areas,such as Breccia Cliff at Candi Ijo (Prambanan) and Ancient Nglanggeran Volcano (Gunungkidul), irrigation development in the area and other supporting infrastructure facilitiyconstructionson each geoheritage object.

2.1 Geological Setting

Locally, the research area is the body of the river and small hills which have a height of less than 100 m, surrounded byin fertile rice fields. These small hills are composed by Tertiary volcanic rocks, i.e beds of pumice and tuffs of Semilir Formation in the east and south and pyroxenic basalt in the west. The surrounding rice fields consist of Quaternarry fluviovolcanic deposits which are products of Merapi Volcano in the north.

Geologically the study area is covered in the Regional Geological Map of Yogyakarta Sheet (Rahardjo et al., 1995). Basaltic pillow lavasare found in the Kebo-Butak Formation, including Bayat, Tegalrejo and Gunung Sepikul (Bronto et al., 2009). However, pillow lava in Watuadeg is not clearly included in the Kebo-Butak Formation which is because it is not associated with the Kebo-Butak Formation sedimentary rocks and is directly overlain by the Semilir Formation (Bronto et al., 2008; Mulyaningsih & Sanyoto, 2012). The basaltic lava flow is characterized by rich in pyroxene minerals, having pillow structures with N70oE directional flow structure in the north to N150oE in the south, located on the Opak River body. At 200 m to the west there is a small hill which is also composed by basalt pyroxene, the results of the K / Ar age analysis find data 56.3 ± 3.8 Ma (Ngkoimani, 2004).

3. Method

The study uses qualitative and quantitative primary and secondary data. The primary data collected during field observation, include distributing the questionairre for people around the study area and educational people including students and the other visitors. An other primary data were observations of geomorphological, cultural, social and economical changes before and after geoheritage's development. All data has been compilled using overlay system.

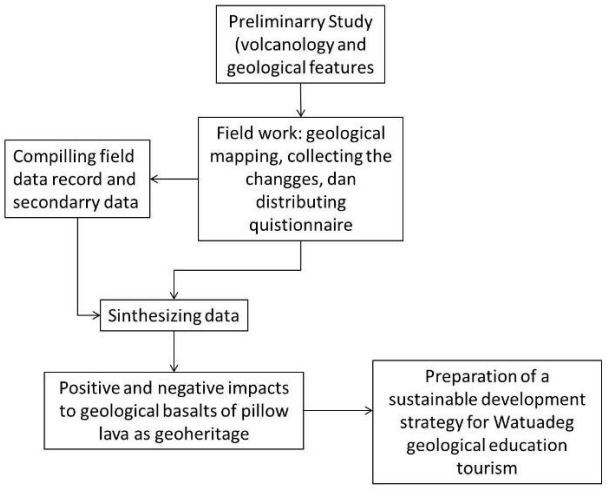

Fig. 2 Flow chart diagram of the method of study.

Data from observations in the field, collection of questionnaires, changes in landforms before and after the Watuadeg Pillow Lava tour are then tabulated, and a graph is prepared explaining the positive and negative impacts. From the results of the statistical data analysis, further improvement measures are planned, which may be done in order to reduce the rate of change in geomorphology, social, economic, cultural and ecosystem. The method can be read in Fig. 2.

4. Result

From the results of the study observed in the siteof Watuadegpillow lava, there were many damages which made during the development of the geoheritage site so that become not maintained, thus reducing the value of education and attractiveness especially in the geological context. Evidence of damage to the geoheritage site of WatuadegPillow Lava is the construction of irrigation by the local government which is the function of irrigation development, namely for surface water channels and for the availability of water for agriculture. However, the development of irrigation in the beds of pumice and tuffsof Semilir Formation arround it is very influential on the geological history and geological processes that occur and take place in the area, especially as stratigraphic correlation data that connecting the surrounding rocks.

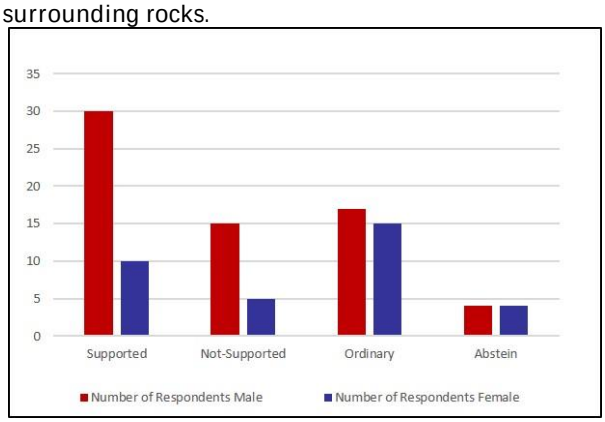

Fig 2. Graph of improving the economy of the people towards the existence of Watuadeg geoheritage.

The dissemination of the tracking questionnaire for the level of satisfaction of citizens towards the existence of Watuadeg geoheritage has been carried out based on its response to improving the economic level of citizens, social and culture. Tracking results found that most of the residents felt economically assisted in relation to parking, ticketing, security and culinary arrangements (Fig. 2). Based on social and cultural tracking, the existence of the geoheritage has changed the behavior of the people from those who initially worked as construction laborers, so now most of the young people switch professions as local guides and event presenters (Fig. 3).

Questionnaires were also given to the academic community, including students, researchers, lecturers and secondary school students. The average respondent feels that the development of geoheritage has changed the educational zone into an exclusive zone, which can only be entered by tourists. Students who have been able to freely visit, do research and learn about ancient volcanoes of Watuadeg and Semilir, can no longer find contact between the rock members of the Semilir Formation and the basalt pillow lava. In addition, several parts of the pillow body that have a specific flow direction have been cut during the construction.Figure 4 is the result of tracking the response of academics in addressing the existence of Watuadeg geoheritage.

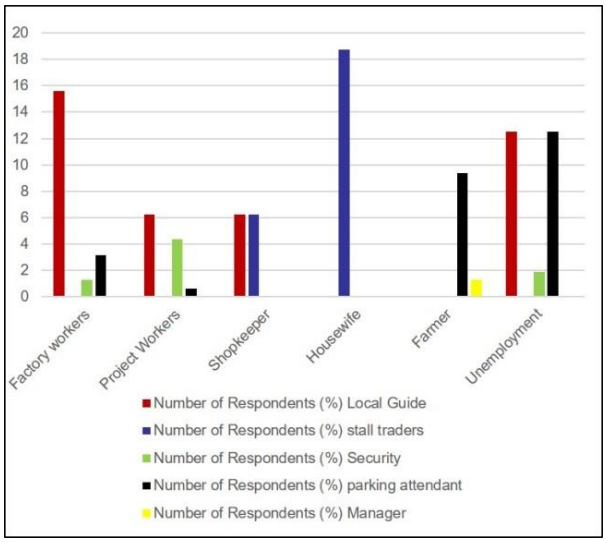

Fig 3. Graph of providing employment for the people towards the existence of Watuadeg geoheritage.

Stratigraphically, the position of the basalt lava with a pillow structure in the Opak River (Watuadeg) is located below the Semilir Formation. Radiometric analysis with the K-Ar method gave the age of 56.3 ± 3.8 million years ago (Late Paleocene), while the age of the Semilir Formation was the Early Miocene - early Middle Miocene (Surono et al., 1992; Rahardjo, 2007) or about 16 million years ago. The pillow lava age was older than the pillow lava age in Pacitan (42.73 ± 9.78 - 33.56 ± 9.69; Soeria-Atmadja et al., 1994), so re-testing was needed. But if it is true, or at least equal to Pacitan pillow lava age, a very long period of time (17-40 million years) between pillow Watuadeg lava formation and sedimentation of Semilir Formation has occurred. This very long period of time allowed tectonic deformation and various other geological processes to occur after Watuadeg pillow lava volcanism but before the formation of Semilir Formation. One of them is the possibility of an inconsistency between the two. In addition to age, evidence of non-alignment and a very long grace period can be viewed from the aspects of sedimentology, magmatism and volcanism.

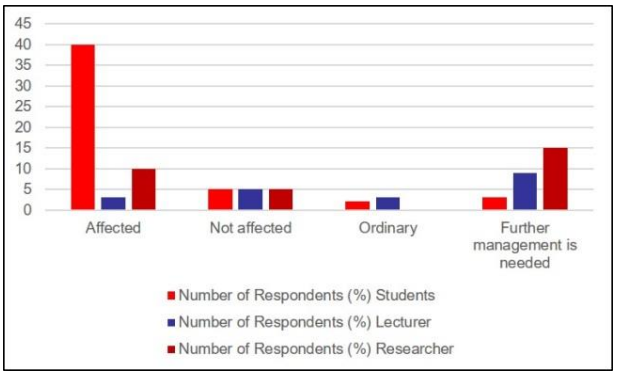

Fig 4. Graph of providing employment for the people towards the existence of Watuadeg geoheritage.

Observations in the field on the existence of Watuadeg geoheritage encountered changes in land use.It has occurred along the riverbanks and hills geomorphology located the south, southeast to the east. These changes need to be done in relation to the potential mass movements taking place within the region. This is mainly found on the south side of the river wall, which is composed by Quaternary fluviovolcanic deposits and distal lahars. Another change occurred on the north side, which is located under the bridge, the area has been covered with cement, so it does not allow visitors to learn the boundaries or contact unconformity between the basalt pillow lava with layers of pumice breccias and tuffsabove it.

To explain the absence of the unconformity boundary, it is still uncovered as well as rocks which consist of basalt breccias on the southern side of the Opak River. However, the riverbed cannot be observed properly when it flows by river water, especially in the rainy season, where river water always overflows in the basalt body of the pillow lava in it. The non-alignment limit is characterized by the presence of basalt fragments floating in the tuff and pumice matrix (Fig. 6).

The other damage is the taking ofpillow lavas to be used as agate done by the surrounding community, thus making the geometry of the pillow lava increasingly unattended and changing from its original condition. From the damage and changes that occur, so that it can reduce geological data that should be very important and useful when used for geological research related to submarine ancient volcano.Behind the efforts to develop the geoherotage, the government actually has a noble goal of enhancing the standard of living of the surrounding communities, thus becoming a positive added value to the region.

Fig 5. The geomorphological changes at Watuadeg geoheritage fields; clockwise is Watuadeg River before the development of geoheritage, after development, the educational area that has not found basal breccia and before development.

In addition, the development of tourism-based geoheritage also aims to increase the number of tourist visits, especially special interests, both domestic and foreign. Unfortunately, this is not offset by the protection of educational points, which of course not all regions in Yogyakarta and Java generally have it. In this case, managers, government and academics sit together to discuss points with educational values that must be protected.

5. Discussion

As mention above, development area to be a main tourism destination, always change the morphology and use of the land. Biodiversity loss as a consequence of the forest disturbance in the Bromo-Tengger-Arjuno-Welirang geotourism and geoheritage has been reported by Hakim et al. (2017). This conflict causes biodiversity to decrease in various ways, through (1) intensive withdrawn forest resources and (2) conversion of forest into farmland. To reduce the impact to the forest biodiversity, the management . The government policy to preserve the pillow lava geoheritage site in Watuadeg-Berbah has not fully done well. Government regulation in terms of granting building permits for building geoheritage areas. In relation to conservation efforts, a place that becomes a geoheritage area must be protected and preserved so that it does not change the shape of the landscape because it already has the legal power of the Geological Agency. This is of course very unfortunate with what is happening now, and the role of the regional government must make efforts and consequences to establish an area as a tourist attraction as well as fight for it to become a protected geological reserve. Therefore in this case the government must be assertive and improve coordination on the granting of building permits to prevent further damage to the geoheritage site of Watuadeg-Berbah pillow lava.

The beauty and uniqueness of the Watuadeg pillow lava that has been set by the Geological Agency of the Ministry of Energy and Mineral Resources as a geological heritage is indeed extraordinary. The presence of large boulders in a round shape, a little like a pillow, pops up not only at the edge of the river, but sometimes in the middle of Opak River ripples. But along with the times, this nature reserve site has become uncontrollable in its development, and precisely reduces the value of uniqueness and its geological history is very unfortunate.

To protect this site especially for the development of protected geological reserves, geoconservation is necessary. The important role of geologists is to provide an understanding of the importance of the site. Besides that, it must also provide information such as making sign boards and mapping them. From the other side, geologiawan must socialize to all stakeholders, tourism awareness groups (POKDARWIS) and local residents to be able to independently manage and utilize the geotourism potential as well as protect it.

Fig 6. The outcrop's changes at Watuadeg geoheritage fields; clockwise is morphology before the development of geoheritage, after development (with Joglo-house), the educational area of basal breccia:dry (dry season) and wet (rainy season); now both are not revealed anymore.

Conclusion

The naturereserve site of pillow lava in Watuadeg-Berbah has undergone significant changes in geological and economic, social and cultural aspects. On the other hand, the development of Watuadeg geoheritage has had a positive impact, in the form of the availability of infrastructure that can participate in increasing the potential value of the region and the standard of living, social, cultural and economic community. Weighting between positive and negative values, of course cannot be done only unilaterally. Comprehensive study is needed about the management system which can also be protected by geological reserves.

The commitment of local governments, communities and academics in conserving the site of pillow lava and fighting them to become conserved; will not be in vain if all components are aware of the limitations of the conservingin it. The important role of the geologists is needed to provide understanding, training and brief teaching on geology and geological processes that might occur, related to the ancient volcanic geological reserve at Watuadeg.

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